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Fukui

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(54) **PORTABLE TERMINAL AND PORTABLE TERMINAL SYSTEM**

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H04R 1/10	(2006.01)
H04R 17/00	(2006.01)
H04R 3/00	(2006.01)

(52) **U.S. Cl.**

CPC ***H04R 1/1083*** (2013.01); ***H04R 1/1041*** (2013.01); *H04R 3/005* (2013.01); *H04R 17/00* (2013.01); *H04R 2420/01* (2013.01); *H04R 2460/13* (2013.01)

(58) **Field of Classification Search**

CPC .. H04R 1/1075; H04R 1/1008; H04R 1/1016; H04R 2499/11; H04R 25/558; H04R 3/005

USPC 381/56, 119, 370, 373; 704/233

See application file for complete search history.

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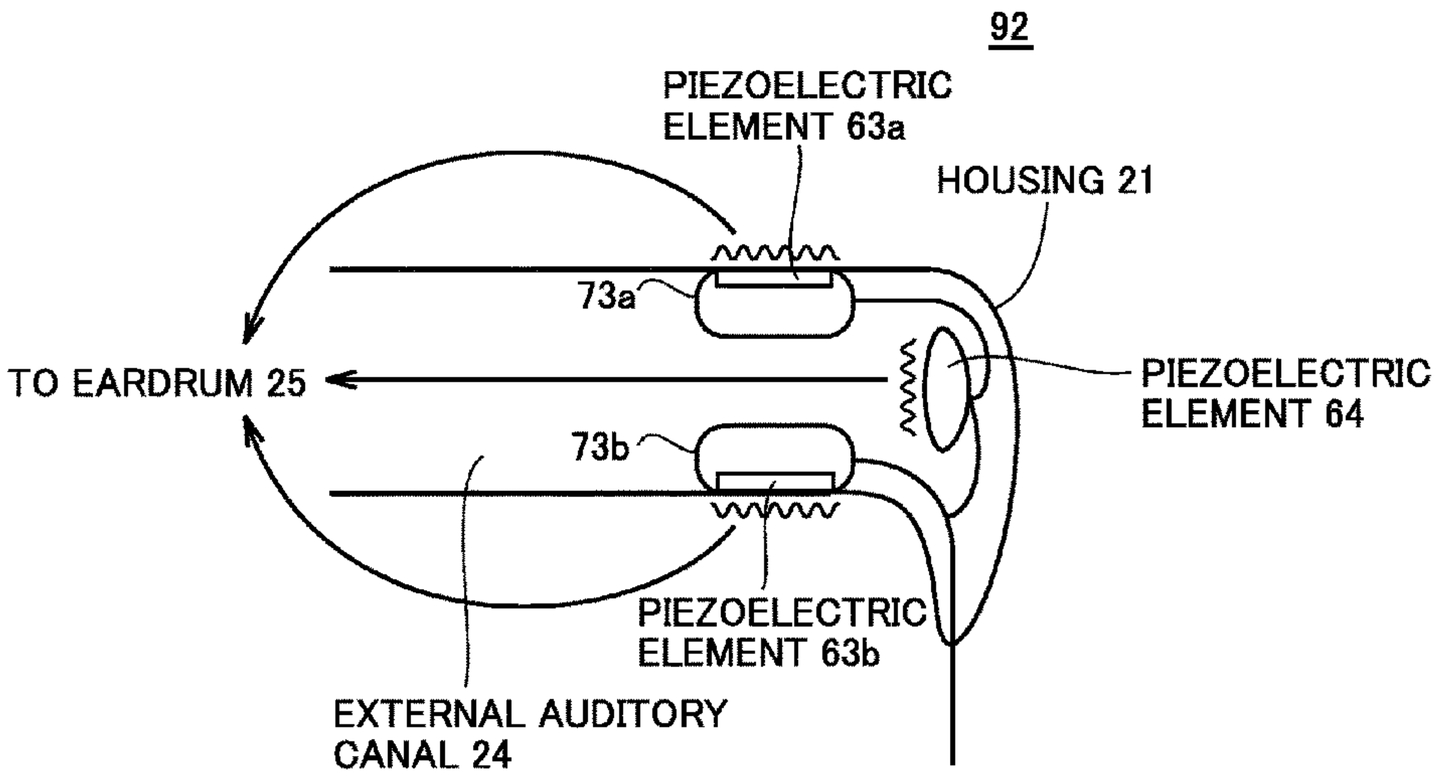
(57) **ABSTRACT**

A portable terminal and a portable terminal system that allows a user to hear an ambient sound highly necessary for the user while wearing an earphone on his/her ear are provided. An ambient sound output determination module is configured to determine whether or not an ambient sound should be output to the earphone based on a sound signal received from at least one microphone of a first microphone and a second microphone. A sound output control module is configured to output the sound signal received from the at least one microphone to the earphone if it is determined that the ambient sound should be output to the earphone.

4 Claims, 9 Drawing Sheets



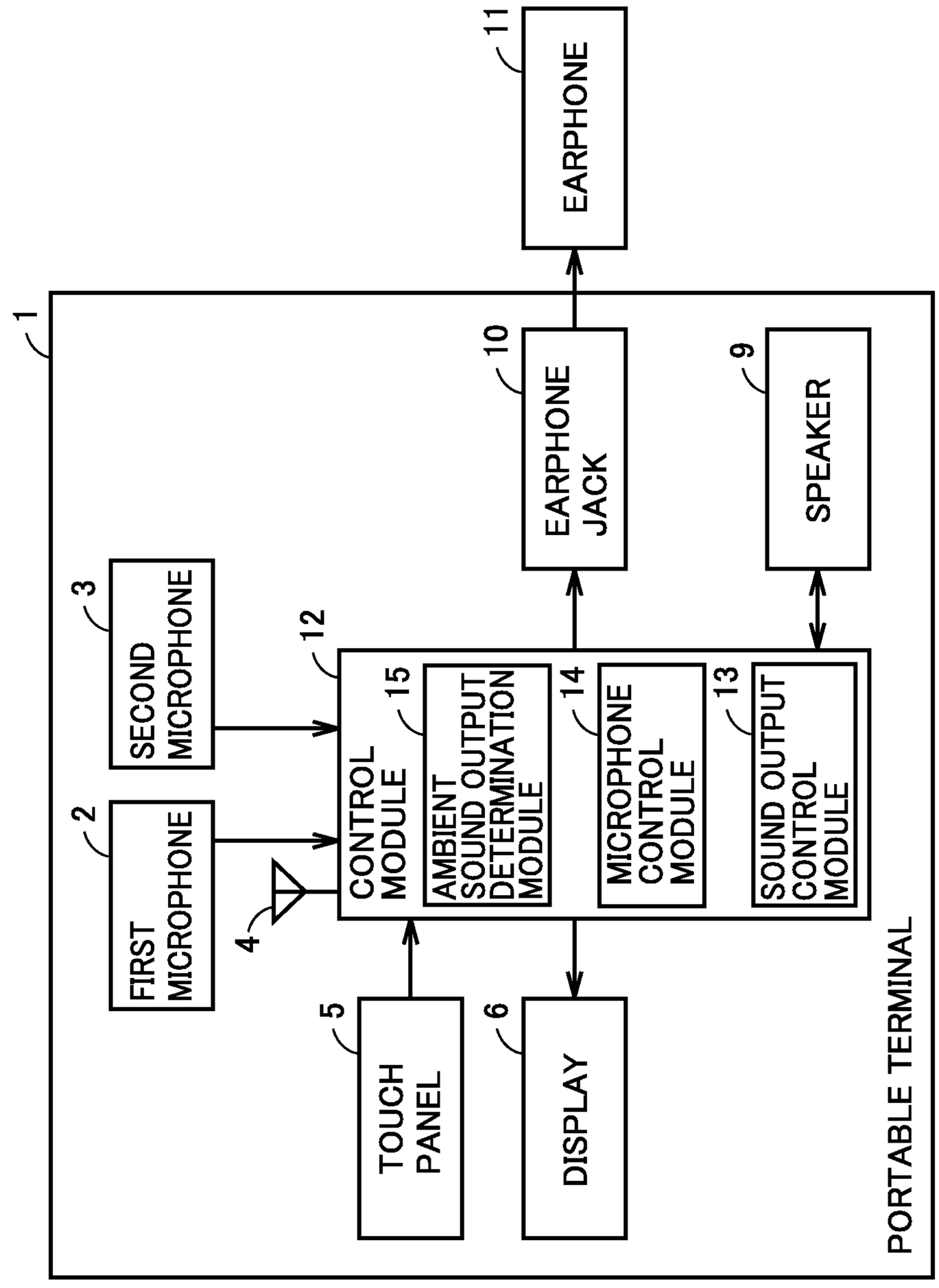

11
EARPHONE
1
10
EARPHONE JACK
9
SPEAKER
3
SECOND MICROPHONE
12
15
AMBIENT SOUND OUTPUT DETERMINATION MODULE
14
MICROPHONE CONTROL MODULE
13
SOUND OUTPUT CONTROL MODULE
2
FIRST MICROPHONE
CONTROL MODULE
4
5
TOUCH PANEL
6
DISPLAY
PORTABLE TERMINAL

FIG.1

FIG.2

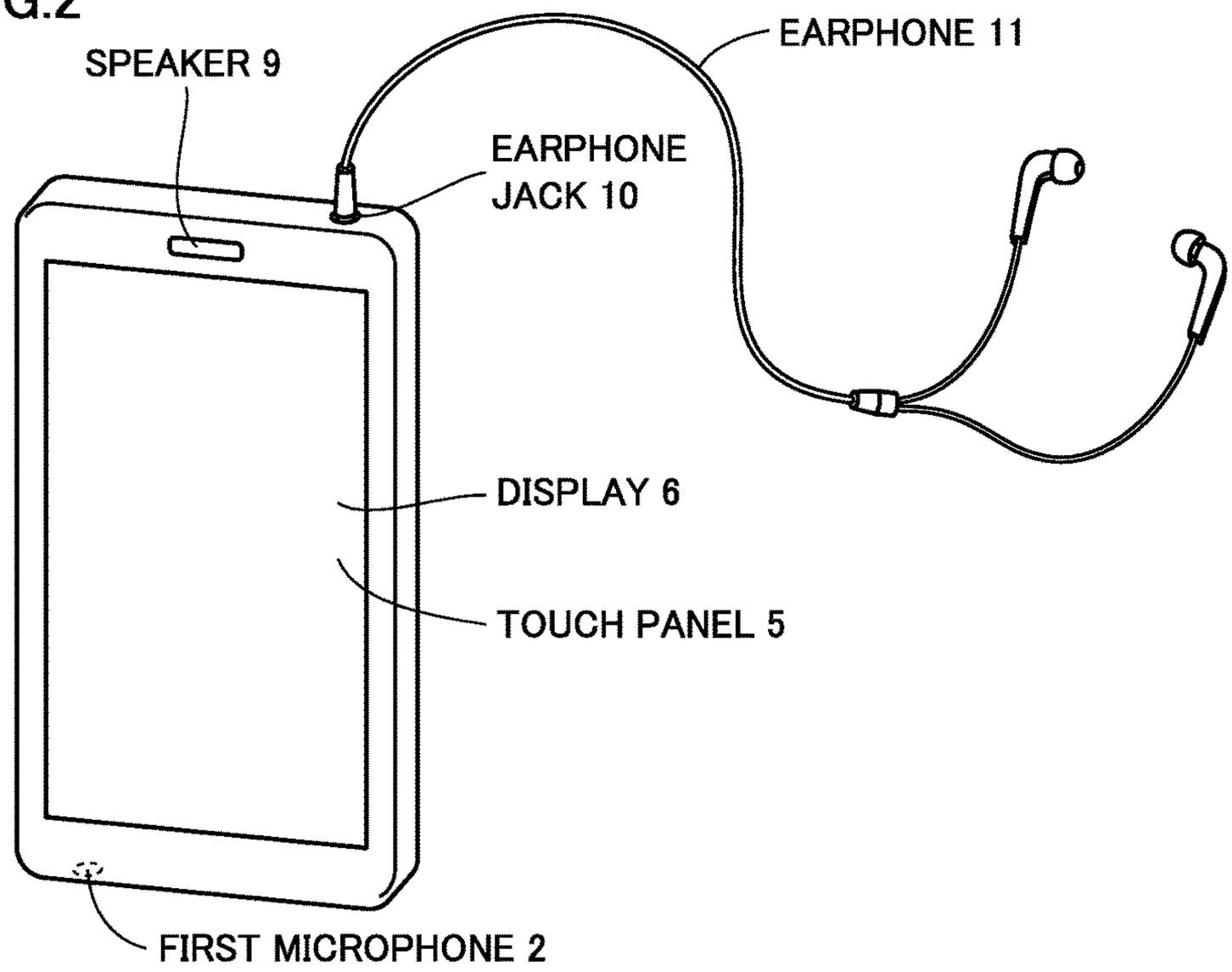

SPEAKER 9
EARPHONE 11
EARPHONE JACK 10
DISPLAY 6
TOUCH PANEL 5
FIRST MICROPHONE 2

FIG.3

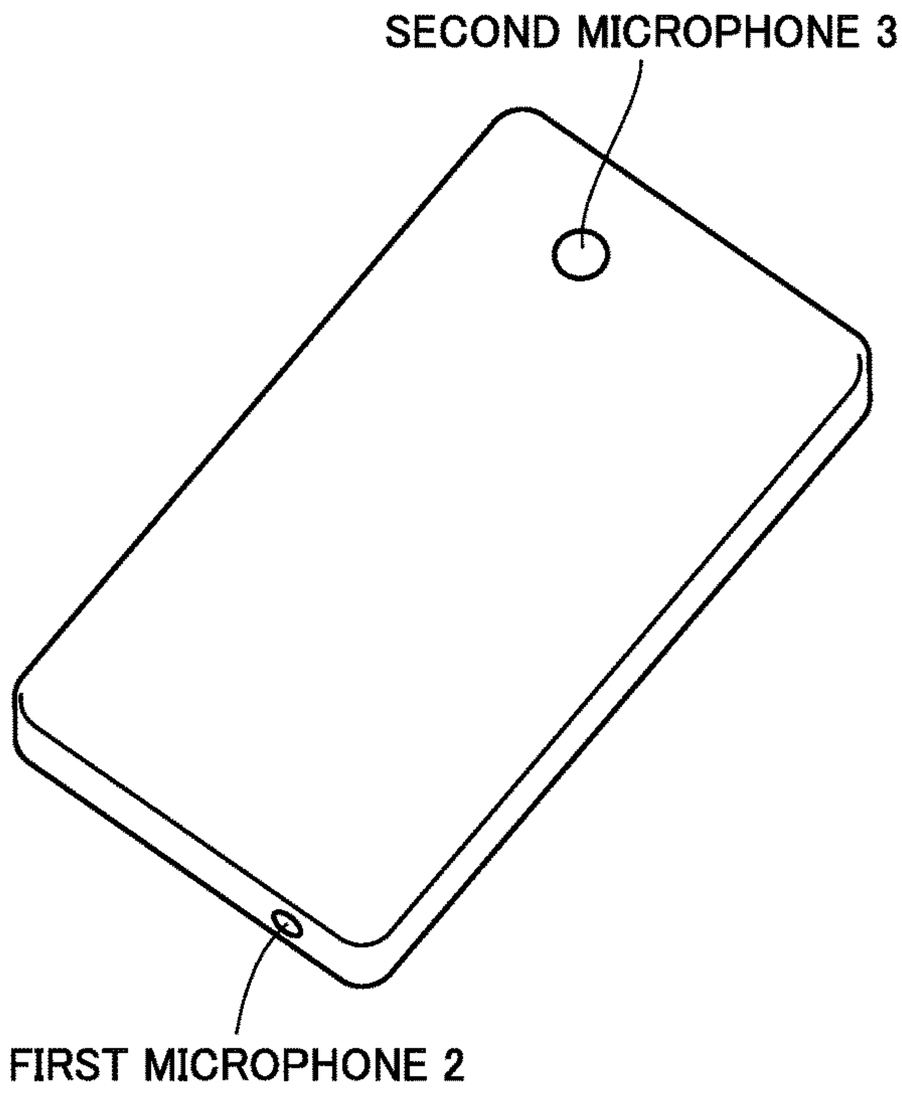
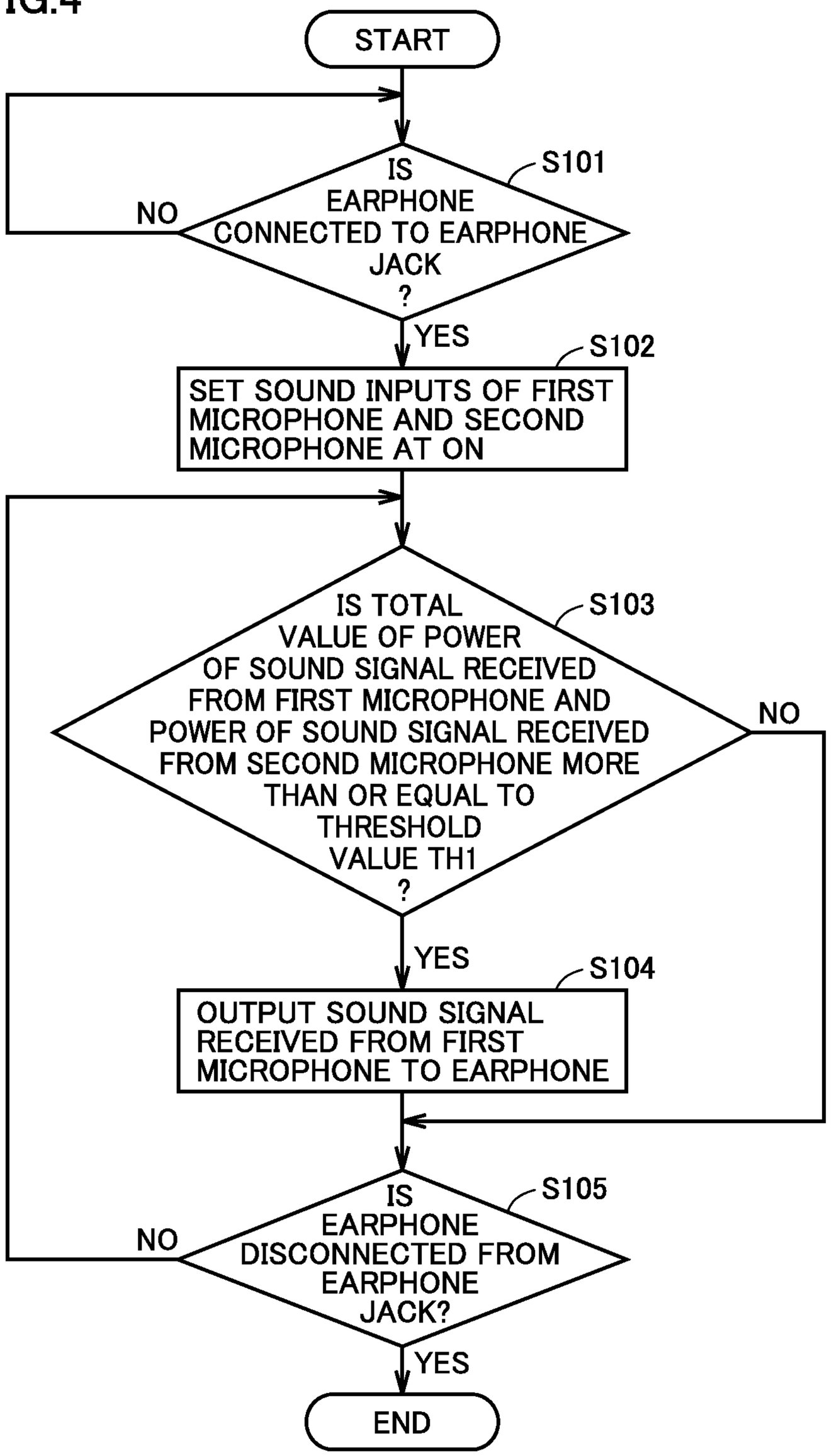

SECOND MICROPHONE 3
FIRST MICROPHONE 2

FIG.4


START
S101
IS EARPHONE CONNECTED TO EARPHONE JACK ?
NO
YES
S102
SET SOUND INPUTS OF FIRST MICROPHONE AND SECOND MICROPHONE AT ON
S103
IS TOTAL VALUE OF POWER OF SOUND SIGNAL RECEIVED FROM FIRST MICROPHONE AND POWER OF SOUND SIGNAL RECEIVED FROM SECOND MICROPHONE MORE THAN OR EQUAL TO THRESHOLD VALUE TH1 ?
NO
YES
S104
OUTPUT SOUND SIGNAL RECEIVED FROM FIRST MICROPHONE TO EARPHONE
S105
IS EARPHONE DISCONNECTED FROM EARPHONE JACK?
NO
YES
END

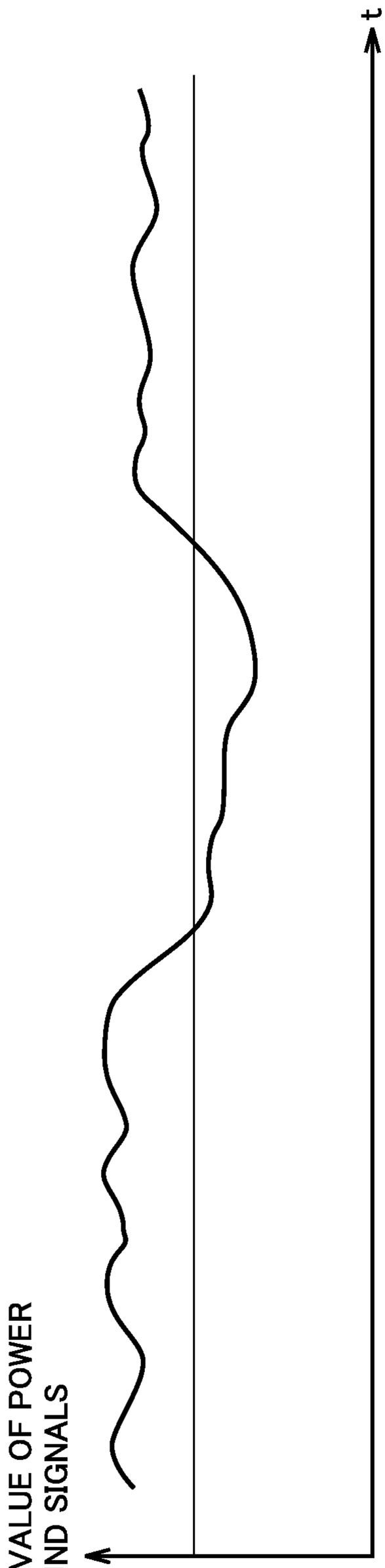
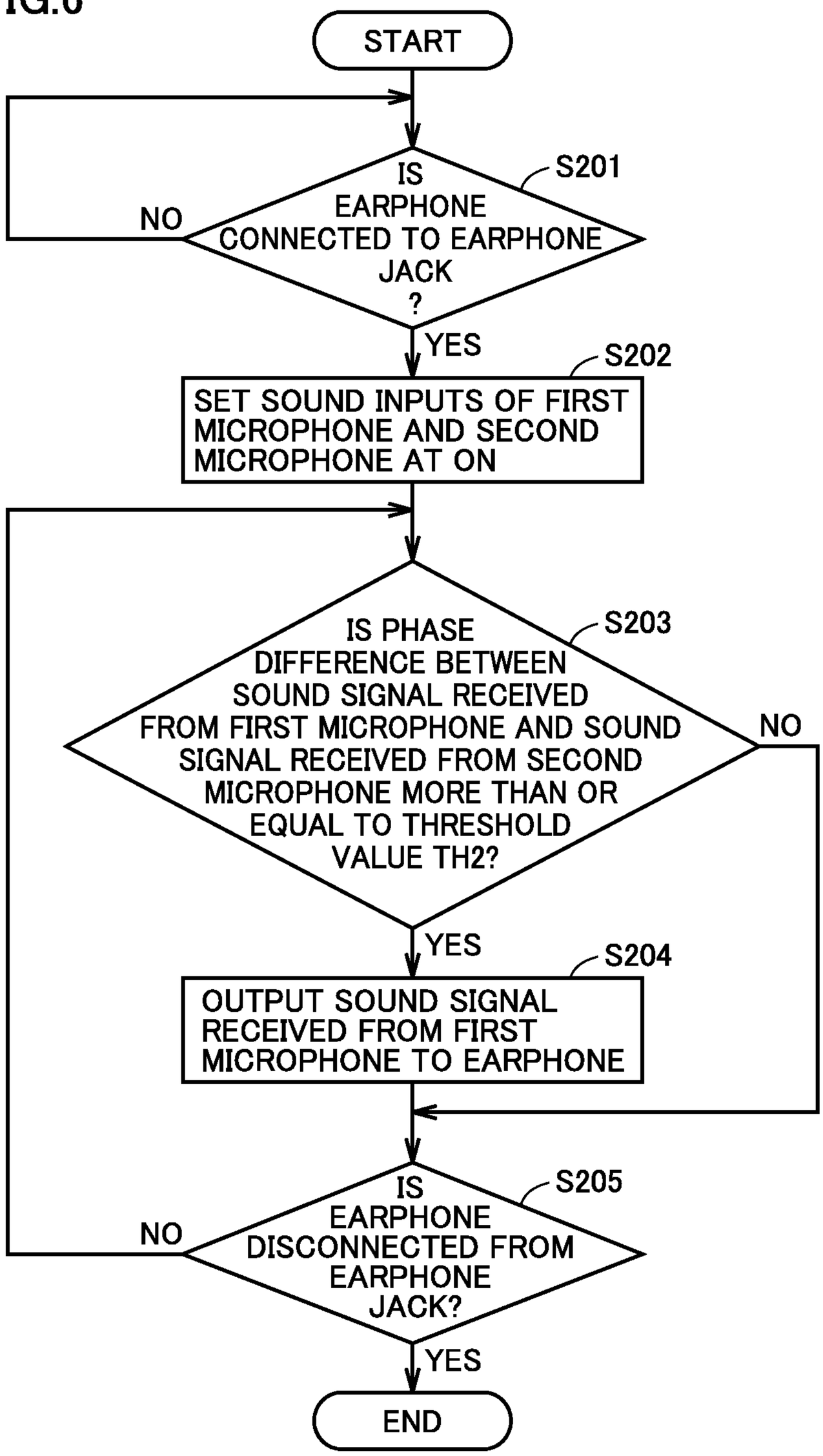


FIG.5

FIG.6


START
S201
IS EARPHONE CONNECTED TO EARPHONE JACK ?
NO
YES
S202
SET SOUND INPUTS OF FIRST MICROPHONE AND SECOND MICROPHONE AT ON
S203
IS PHASE DIFFERENCE BETWEEN SOUND SIGNAL RECEIVED FROM FIRST MICROPHONE AND SOUND SIGNAL RECEIVED FROM SECOND MICROPHONE MORE THAN OR EQUAL TO THRESHOLD VALUE TH2?
NO
YES
S204
OUTPUT SOUND SIGNAL RECEIVED FROM FIRST MICROPHONE TO EARPHONE
S205
IS EARPHONE DISCONNECTED FROM EARPHONE JACK?
NO
YES
END

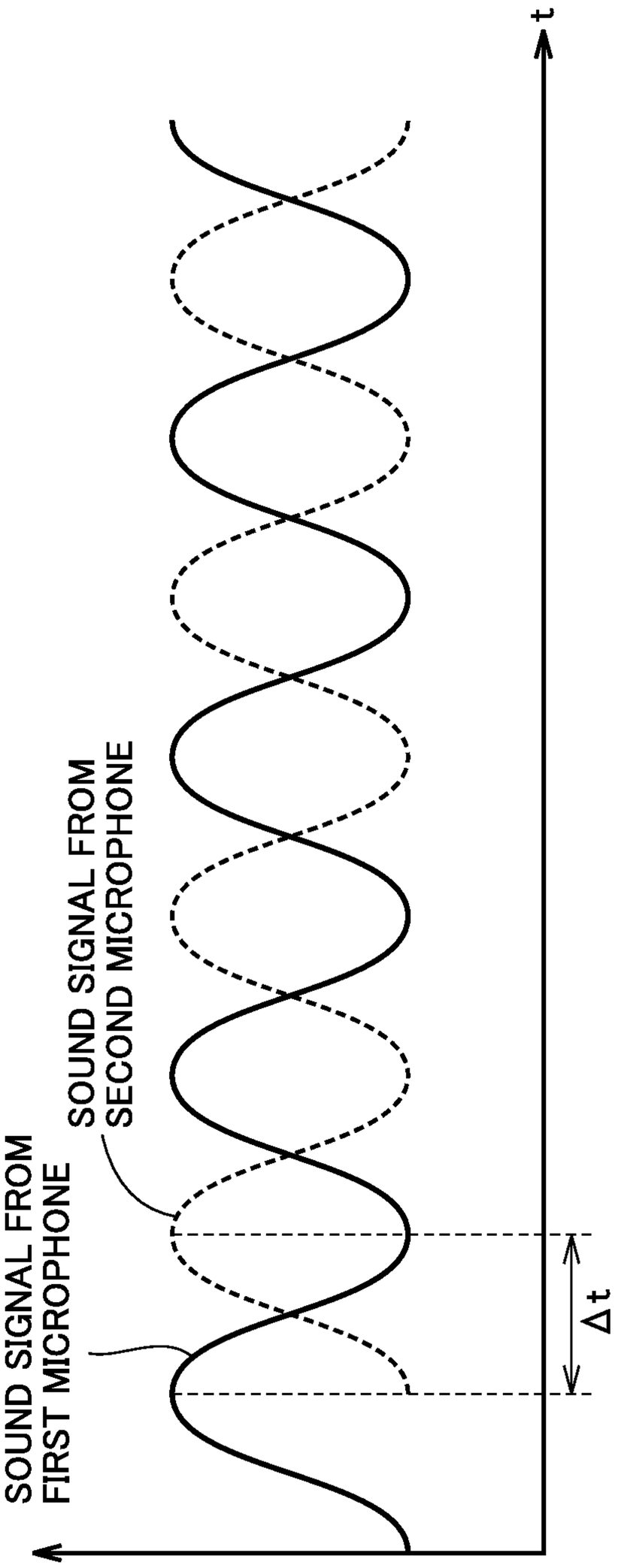
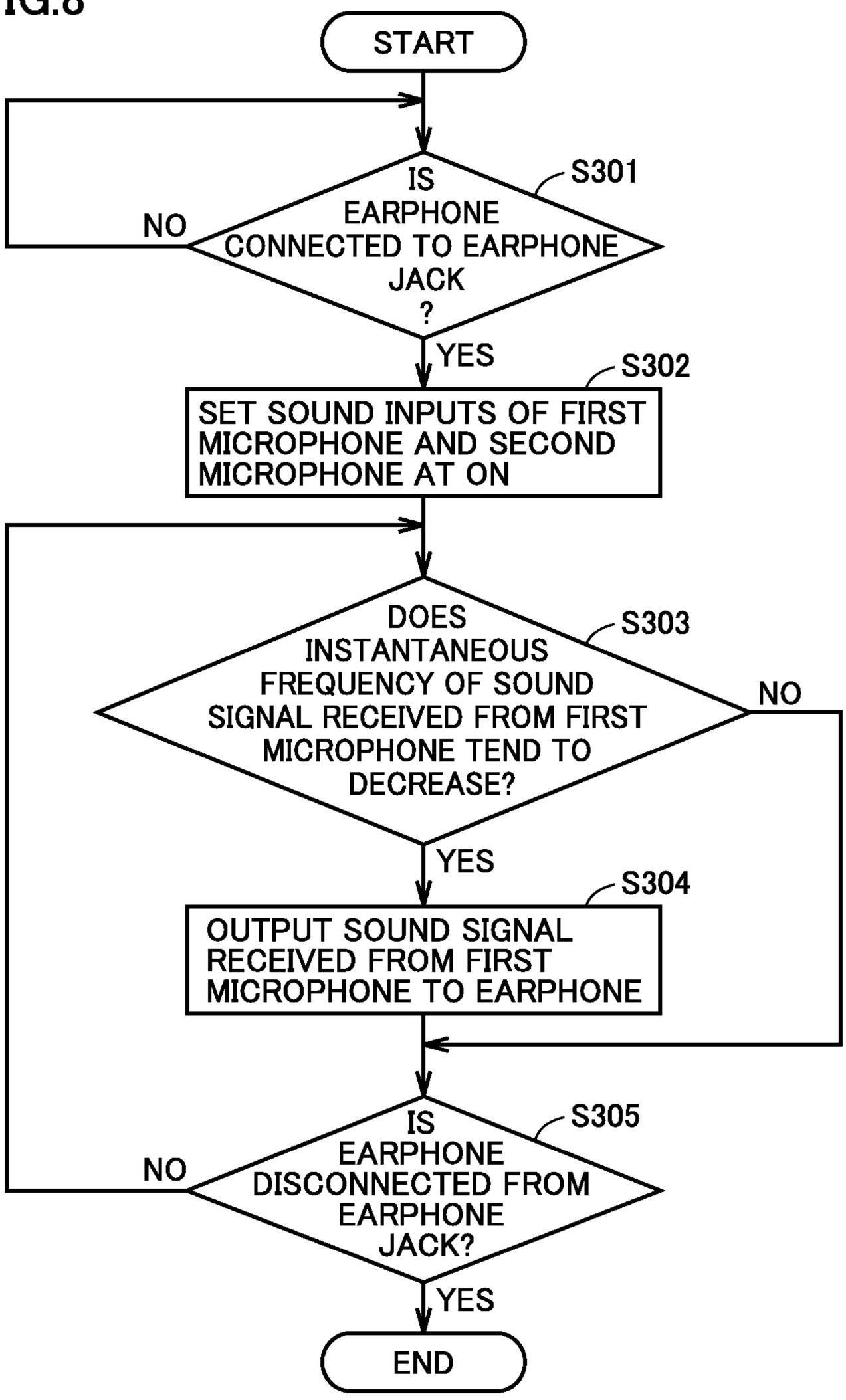

t
SOUND SIGNAL FROM SECOND MICROPHONE
SOUND SIGNAL FROM FIRST MICROPHONE
Δt

FIG.7

FIG.8


START
IS EARPHONE CONNECTED TO EARPHONE JACK ?
S301
NO
YES
SET SOUND INPUTS OF FIRST MICROPHONE AND SECOND MICROPHONE AT ON
S302
DOES INSTANTANEOUS FREQUENCY OF SOUND SIGNAL RECEIVED FROM FIRST MICROPHONE TEND TO DECREASE?
S303
NO
YES
OUTPUT SOUND SIGNAL RECEIVED FROM FIRST MICROPHONE TO EARPHONE
S304
IS EARPHONE DISCONNECTED FROM EARPHONE JACK?
S305
NO
YES
END

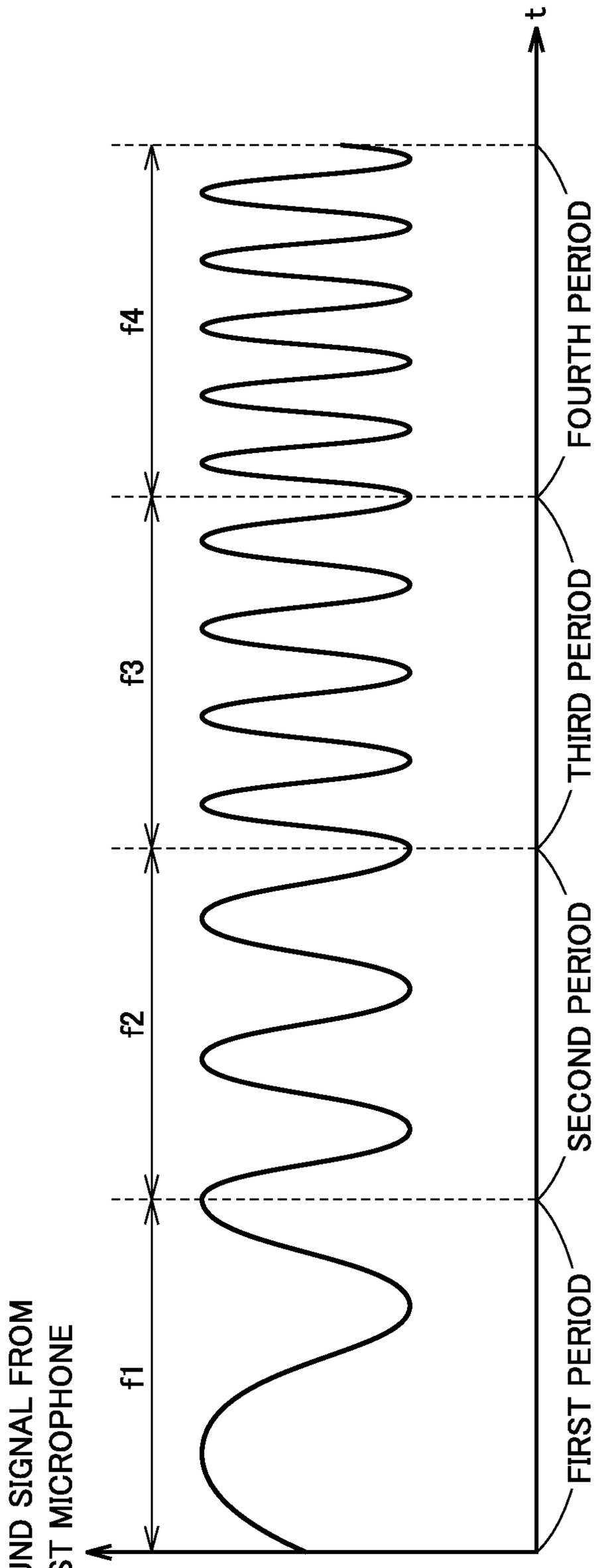

SOUND SIGNAL FROM FIRST MICROPHONE
t
f1
f2
f3
f4
FIRST PERIOD
SECOND PERIOD
THIRD PERIOD
FOURTH PERIOD

FIG.9

FIG.10

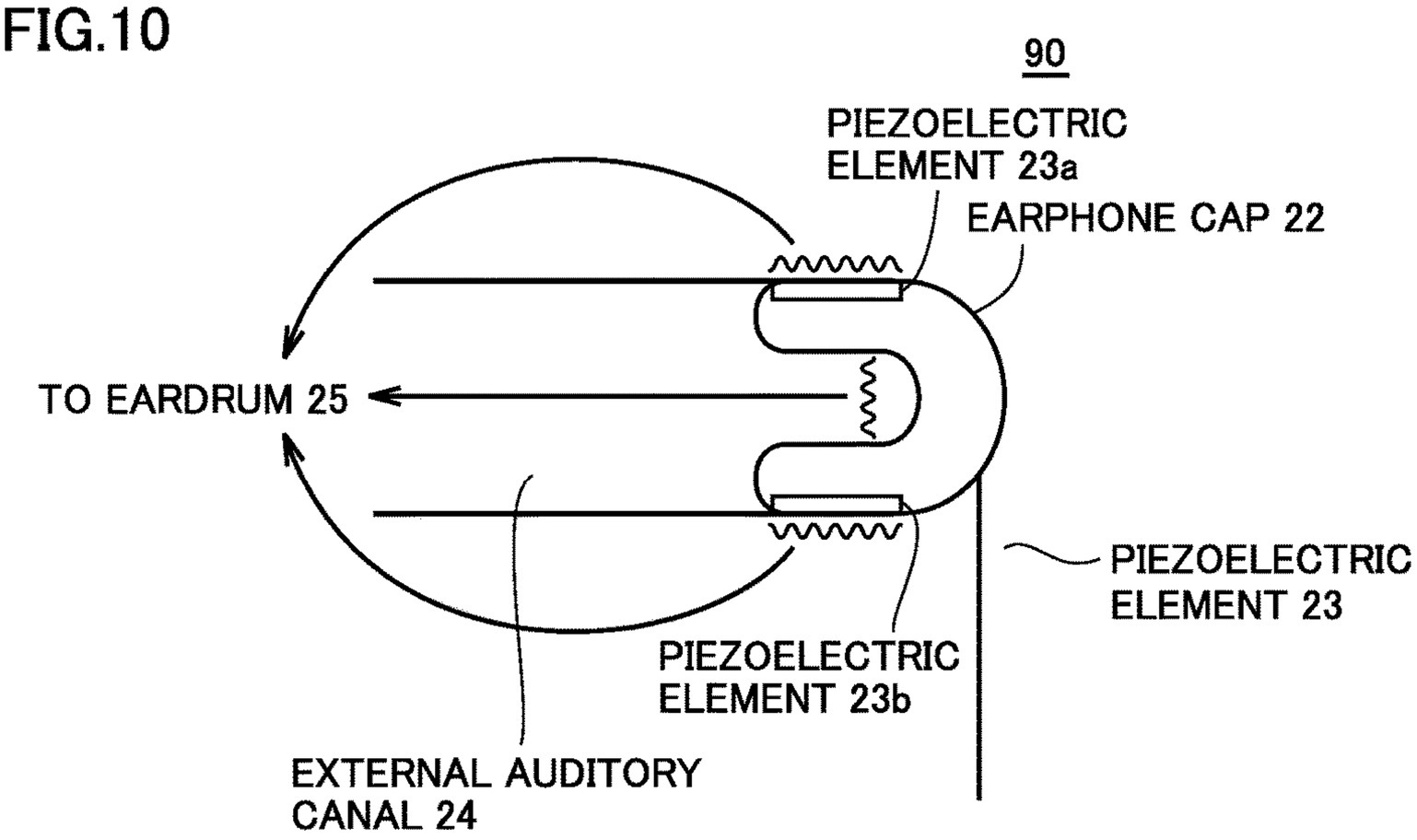
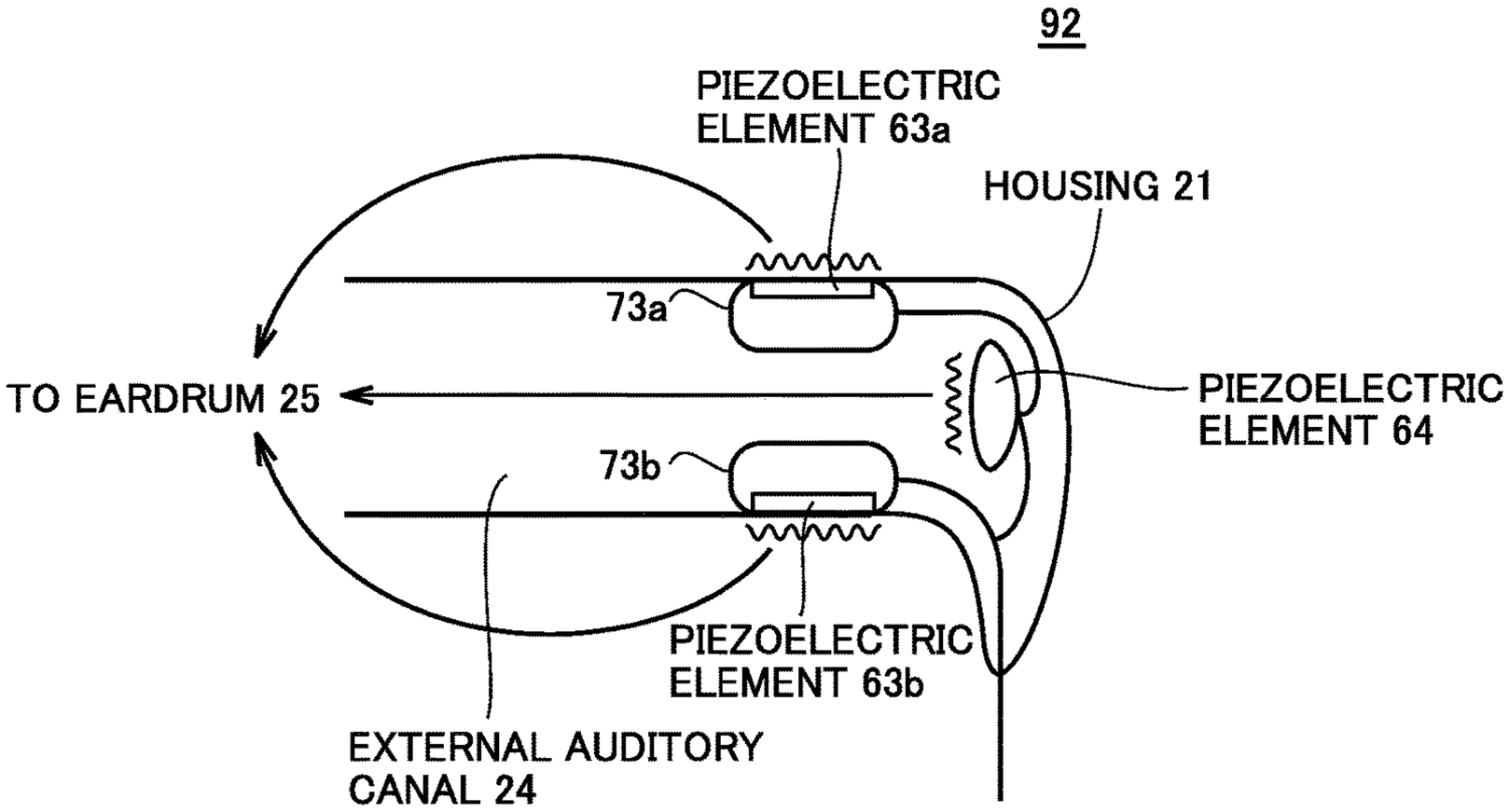

90
PIEZOELECTRIC ELEMENT 23a
EARPHONE CAP 22
TO EARDRUM 25
PIEZOELECTRIC ELEMENT 23
PIEZOELECTRIC ELEMENT 23b
EXTERNAL AUDITORY CANAL 24

FIG.11


92
PIEZOELECTRIC ELEMENT 63a
HOUSING 21
73a
TO EARDRUM 25
PIEZOELECTRIC ELEMENT 64
73b
PIEZOELECTRIC ELEMENT 63b
EXTERNAL AUDITORY CANAL 24

PORTABLE TERMINAL AND PORTABLE TERMINAL SYSTEM

CROSS-REFERENCE TO RELATED APPLICATION

The present application claims priority under 35 U.S.C. §119 to Japanese Patent Application No. 2014-090366, filed on Apr. 24, 2014, entitled "Portable Terminal and Portable Terminal System." The content of which is incorporated by reference herein in its entirety.

FIELD

The present disclosure relates to a portable terminal and a portable terminal system, and more particularly to a portable terminal and a portable terminal system having a function of outputting sound to an earphone.

BACKGROUND

There is a conventionally known technique in which a user can hear an ambient sound when an earphone is connected to a portable terminal.

SUMMARY

A portable terminal according to one embodiment includes one or more microphones, a determination module configured to determine whether or not an ambient sound should be output to an earphone based on a sound signal received from at least one microphone among the one or more microphones, and a sound output control module configured to output the sound signal received from the at least one microphone to the earphone if it is determined that the ambient sound should be output to the earphone.

The foregoing and other objects, features, aspects and advantages of the present disclosure will become more apparent from the following detailed description of the present disclosure when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagram representing a configuration of a portable terminal according to an embodiment.

FIG. **2** is a diagram representing an appearance of the portable terminal.

FIG. **3** is a diagram representing an appearance of the portable terminal.

FIG. **4** is a flowchart representing a control procedure for outputting an ambient sound to an earphone by a portable terminal according to a first embodiment.

FIG. **5** is a diagram representing an example of a sound signal when outputting an ambient sound in the first embodiment.

FIG. **6** is a flowchart representing a control procedure for outputting an ambient sound to an earphone by a portable terminal according to a second embodiment.

FIG. **7** is a diagram representing an example of a sound signal when outputting an ambient sound in the second embodiment.

FIG. **8** is a flowchart representing a control procedure for outputting an ambient sound to an earphone by a portable terminal according to a third embodiment.

FIG. **9** is a diagram representing an example of a sound signal when outputting an ambient sound in the third embodiment.

FIG. **10** is a diagram representing an appearance of an earphone according to a fourth embodiment.

FIG. **11** is a diagram representing an appearance of an earphone according to a fifth embodiment.

DETAILED DESCRIPTION

Hereinafter, embodiments will be described with reference to the drawings.

Ambient sounds for a portable terminal include sounds necessary for a user (e.g., the voice of another person talking to the user, a horn sound of a vehicle, and a siren sound of an emergency vehicle) and sounds unnecessary for a user (e.g., noise and a conversation between other persons). Conventionally, when a headset is connected to a portable terminal, ambient sounds may always be output to an earphone, whether they are necessary for a user or not. A system for solving such a problem will be disclosed.

First Embodiment

FIG. **1** is a diagram representing a configuration of a portable terminal according to an embodiment. FIGS. **2** and **3** are diagrams each representing an appearance of the portable terminal.

As shown in FIG. **1**, this portable terminal **1** includes an antenna **4**, a touch panel **5**, a display **6**, a first microphone **2**, a second microphone **3**, an earphone jack **10**, a speaker **9**, and a control module **12**.

Control module **12** includes a CPU, a memory module, and the like. By controlling other components of portable terminal **1**, control module **12** can manage operations of portable terminal **1** as a whole. Control module **12** includes a microphone control module **14** and a sound output control module **13**.

Antenna **4** can be used for wireless communications with a wireless base station.

Touch panel **5** can accept an operation input from a user.

Display **6** can display various types of information such as characters, signs, graphics, and the like.

First microphone **2** and second microphone **3** can convert an ambient sound into a sound signal.

First microphone **2** can be provided in the undersurface of portable terminal **1**, as shown in FIGS. **2** and **3**.

Second microphone **3** can be provided in the rear surface of portable terminal **1**, as shown in FIG. **3**.

Earphone jack **10**, when connected to earphone **11**, can output a sound signal from sound output control module **13** to earphone **11**.

Speaker **9** can generate a sound pressure based on the sound signal output from sound output control module **13**.

When earphone **11** is connected to earphone jack **10**, microphone control module **14** can turn on sound inputs of first microphone **2** and second microphone **3** to receive a sound signal from first microphone **2** and a sound signal from second microphone **3**.

Ambient sound output determination module **15** can determine whether or not an ambient sound should be output to earphone **11** based on the sound signal received from at least one of first microphone **2** and second microphone **3**.

In the first embodiment, ambient sound output determination module **15** can detect power of the sound signals received from first microphone **2** and second microphone **3**, and when the sum of detected power of the sound signals is

more than or equal to a threshold value, can determine that an ambient sound should be output to earphone **11**.

When earphone **11** is not connected to earphone jack **10**, sound output control module **13** can output a sound signal reproduced in portable terminal **1** by an application program or the like to speaker **9**.

When earphone **11** is connected to earphone jack **10**, if it is not determined by ambient sound output determination module **15** that an ambient sound should be output to earphone **11** and if a sound signal is being reproduced by an application program or the like, sound output control module **13** can output the sound signal reproduced in portable terminal **1** by the application program or the like to earphone **11** through earphone jack **10**.

For example, while a user is on the phone, when a call partner is talking and the user is not, the call partner's voice reproduced by a call application can be output to earphone **11**.

When earphone **11** is connected to earphone jack **10**, if it is determined by ambient sound output determination module **15** that an ambient sound should be output to earphone **11** and if a sound signal is not being reproduced by the application program or the like, sound output control module **13** can output the sound signal received from first microphone **2** to earphone **11** through earphone jack **10**.

For example, while a user is on the phone, and if the user is talking and a call partner is not, an ambient sound including the user's voice can be output to earphone **11**.

When earphone **11** is connected to earphone jack **10**, if it is determined by ambient sound output determination module **15** that an ambient sound should be output to earphone **11** and if a sound signal is being reproduced by the application program or the like, sound output control module **13** can synthesize a sound signal received from first microphone **2** and the sound signal reproduced by the application program or the like for output to earphone **11** through earphone jack **10**.

For example, while a user is on the phone, and if a call partner is talking and the user is talking, the call partner's voice reproduced by the call application and an ambient sound including the user's voice can be synthesized and output to earphone **11**.

FIG. **4** is a flowchart representing a control procedure for outputting an ambient sound to an earphone by a portable terminal according to the first embodiment.

In step S**101**, when earphone **11** is connected to earphone jack **10** (YES in step S**101**), the process proceeds to step S**102**.

In step S**102**, microphone control module **14** can set the sound inputs of first microphone **2** and second microphone **3** at the ON state.

In step S**103**, if the total value of power of a sound signal received from first microphone **2** and power of a sound signal received from second microphone **3** is more than or equal to a threshold value TH**1** (YES in step S**103**), the process proceeds to step S**104**.

In step S**104**, ambient sound output determination module **15** can determine that an ambient sound should be output to earphone **11**. Sound output control module **13** can output the sound signal received from first microphone **2** to earphone **11**. When a sound signal is being reproduced by an application program or the like, the sound signal received from first microphone **2** and the reproduced sound signal may be synthesized and output to the earphone.

Since the sound signal received from the first microphone is output to earphone **11** in a period during which the total value of power of sound signals is more than or equal to threshold value TH**1** as shown in FIG. **5**, the user can hear, through earphone **11**, high-volume sounds around the user, such as the voice of another person different from a call partner and talking to the user, a siren sound of a patrol car, a horn sound of a vehicle, and the like.

In step S**105**, processing in steps S**103** and S**104** is repeated until earphone **11** is disconnected from earphone jack **10** (YES in step S**105**).

In the first embodiment, ambient sound output determination module **15** determines that an ambient sound should be output to earphone **11** if the total value of power of a sound signal received from first microphone **2** and power of a sound signal received from second microphone **3** is more than or equal to threshold value TH**1**, but this is not a limitation. Ambient sound output determination module **15** may determine that an ambient sound should be output to earphone **11** if power of the sound signal received from first microphone **2** is more than or equal to the threshold value, if power of the sound signal received from second microphone **3** is more than or equal to the threshold value, or if the average value of power of the sound signal received from first microphone **2** and power of the sound signal received from second microphone **3** is more than or equal to the threshold value.

In the first embodiment, the sound signal received from first microphone **2** shall be output to earphone **11** if it is determined that an ambient sound should be output to earphone **11**, but the sound signal received from second microphone **3** rather than first microphone **2** may be output to earphone **11**. Alternatively, a signal obtained by synthesizing the sound signal received from first microphone **2** and the sound signal received from second microphone **3** may be output to earphone **11**. The same applies to embodiments which will be described later.

As described above, according to the first embodiment, a user can hear, through the earphone, an ambient sound highly necessary for the user which is a high-volume ambient sound, such as the voice of another person talking to the user, a siren sound of a patrol car, or a horn sound of a vehicle.

Second Embodiment

Ambient sound output determination module **15** of portable terminal **1** according to a second embodiment is different from that of the first embodiment.

Ambient sound output determination module **15** according to the second embodiment can detect a phase difference between a sound signal received from first microphone **2** and a sound signal received from second microphone **3**, and when the detected phase difference is more than or equal to a threshold value, can determine that an ambient sound should be output to earphone **11**.

FIG. **6** is a flowchart representing a control procedure for outputting an ambient sound to an earphone by the portable terminal according to the second embodiment.

In step S**201**, when earphone **11** is connected to earphone jack **10** (YES in step S**201**), the process proceeds to step S**202**.

In step S**202**, microphone control module **14** can set the sound inputs of first microphone **2** and second microphone **3** at the ON state.

In step S**203**, if the phase difference between a sound signal received from first microphone **2** and a sound signal received from second microphone **3** is more than or equal to a threshold value TH**2** (YES in step S**203**), the process proceeds to step S**204**.

In step S**204**, ambient sound output determination module **15** can determine that an ambient sound should be output to earphone **11**. Sound output control module **13** can output the sound signal received from first microphone **2** to earphone **11**. When a sound signal is being reproduced by an application program or the like, the sound signal received from first microphone **2** and the reproduced sound signal may be synthesized and output to the earphone.

As shown in FIG. **7**, the phase difference between the sound signal received from first microphone **2** and the sound signal received from second microphone **3** is detected. This phase difference can be detected as a difference Δt between a peak time of the sound signal received from first microphone **2** and a peak time of the sound signal received from second microphone **3**, for example. It can be said that, as Δt is larger, the moving speed of a neighboring sound source is higher. Since the sound signal received from the first microphone is output to earphone **11** in a period during which Δt is more than or equal to threshold values TH**2**, a user can hear, through earphone **11**, a sound of a sound source moving at high speeds around the user, such as a siren sound of a patrol car or a horn sound of a vehicle.

In step S**205**, processing in steps S**203** and S**204** is repeated until earphone **11** is disconnected from earphone jack **10** (YES in step S**205**).

As described above, according to the second embodiment, a user can hear, through the earphone, an ambient sound highly necessary for the user which is the sound of a sound source moving at high speeds around the user, such as a siren sound of a patrol car or a horn sound of a vehicle.

Third Embodiment

Ambient sound output determination module **15** of portable terminal **1** according to a third embodiment is different from those of the first and second embodiments.

Ambient sound output determination module **15** according to the third embodiment can determine that an ambient sound should be output to earphone **11** when the instantaneous frequency of a sound signal received from first microphone **2** exhibits a property that decreases with time.

FIG. **8** is a flowchart representing a control procedure for outputting an ambient sound to an earphone by the portable terminal according to the third embodiment.

In step S**301**, when earphone **11** is connected to earphone jack **10** (YES in step S**301**), the process proceeds to step S**302**.

In step S**302**, microphone control module **14** can set the sound inputs of first microphone **2** and second microphone **3** at the ON state.

In step S**303**, when the instantaneous frequency of a sound signal received from first microphone **2** exhibits a property that decreases with time (YES in step S**303**), the process proceeds to step S**304**. For example, ambient sound output determination module **15** can determine that the instantaneous frequency of a sound signal has a property that decreases with time when the instantaneous frequency decreases continuously in consecutive three periods. When the instantaneous frequency decreases, a neighboring sound source is approaching a user.

In step S**304**, ambient sound output determination module **15** can determine that an ambient sound should be output to earphone **11**. Sound output control module **13** can output the sound signal received from first microphone **2** to earphone **11**. When a sound signal is being reproduced by an application program or the like, the sound signal received from first microphone **2** and the reproduced sound signal may be synthesized and output to the earphone.

As shown in FIG. **9**, the instantaneous frequency of the sound signal received from first microphone **2** is f1, f2, f3, and f4 in first, second, third, and fourth periods, respectively, where f1>f2>f3>f4 holds. Since the instantaneous frequency decreases continuously in consecutive three periods, the sound signal received from the first microphone is output to earphone **11**. The user can thus hear, through earphone **11**, the sound of a sound source approaching him/her, such as a siren sound of a patrol car or a horn sound of a vehicle.

In step S**305**, processing in steps S**303** and S**304** is repeated until earphone **11** is disconnected from earphone jack **10** (YES in step S**305**).

As described above, according to the third embodiment, a user can hear, through the earphone, an ambient sound highly necessary for the user which is the sound of a sound source approaching him/her, such as a siren sound of a patrol car or a horn sound of a vehicle.

In the third embodiment, the ambient sound output determination module detects the instantaneous frequency of the sound signal received from the first microphone, and determines that an ambient sound should be output to earphone **11** when the detected instantaneous frequency has a property that decreases with time, but this is not a limitation. For example, a sound signal received from the second microphone may be used instead of a sound signal received from the first microphone. Alternatively, the ambient sound output determination module may determine that an ambient sound should be output to earphone **11** if the instantaneous frequency of a sound signal received from the first microphone exhibits a property that decreases with time and the instantaneous frequency of a sound signal received from the second microphone exhibits a property that decreases with time.

Fourth Embodiment

FIG. **10** is a diagram representing an appearance of an earphone according to a fourth embodiment.

This earphone **90** includes an earphone cap **22**. Piezoelectric elements **23***a* and **23***b* are incorporated in earphone cap **22**.

A user can wear the earphone on his/her ear such that piezoelectric elements **23***a* and **23***b* in earphone cap **22** are in contact with the skin of an external auditory canal. A portion close to the entrance of an external auditory canal **24** is surrounded by cartilages. A portion of external auditory canal **24** closer to the eardrum is surrounded by bones.

Sound output control module **13** of portable terminal **1** according to any of the first to third embodiments can output a sound signal to piezoelectric element **23**.

When piezoelectric elements **23***a* and **23***b* vibrate based on a sound signal output from sound output control module **13**, an air-conducted sound can be supplied to an eardrum **25** through external auditory canal **24**, and a vibration sound can be supplied to eardrum **25** through a bone portion or a cartilaginous portion around external auditory canal **24**.

Fifth Embodiment

FIG. **11** is a diagram representing an appearance of an earphone according to a fifth embodiment.

This earphone **92** includes a housing **21** and piezoelectric elements **63***a*, **63***b* and **64** housed in housing **21**.

Piezoelectric elements **63***a* and **63***b* can be incorporated in earphone caps **73***a* and **73***b*, respectively, and a user can

wear the earphone on his/her ear such that piezoelectric elements **63***a* and **63***b* are in contact with the skin of external auditory canal **24**.

Sound output control module **13** of portable terminal **1** according to any of the first to third embodiments can output a sound signal reproduced by an application of portable terminal **1** or the like to piezoelectric element **64**. When piezoelectric element **64** vibrates based on the received sound signal, an air-conducted sound can be supplied by eardrum **25** through external auditory canal **24**.

When it has been determined by ambient sound output determination module **15** that an ambient sound should be output to the earphone, sound output control module **13** can output a sound signal received from first microphone **2** to piezoelectric elements **63***a* and **63***b*. When piezoelectric elements **63***a* and **63***b* vibrate based on the received sound signal, a vibration sound can be supplied to eardrum **25** through a bone portion or a cartilaginous portion around external auditory canal **24**.

Although embodiments of the present disclosure have been described and illustrated in detail, it is clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation, the scope of the present disclosure being interpreted by the terms of the appended claims.

The invention claimed is:

1. A portable terminal comprising:

an earphone including

a first piezoelectric element configured to vibrate based on a sound signal received from the portable terminal to supply an air-conducted sound to an eardrum through an external auditory canal, and

a second piezoelectric element configured to vibrate based on the sound signal received from the portable terminal to supply a vibration sound to the eardrum through a bone portion or a cartilaginous portion around the external auditory canal;

a plurality of microphones;

a determination module configured to determine whether or not an ambient sound should be output to an earphone based on a sound signal received from at least two of the plurality of microphones by detecting a phase difference between at least two sound signals received from the at least two microphones, and determining that the ambient sound should be output to the earphone when the phase difference between the at least two sound signals is more than or equal to a threshold value, thereby indicating that a source of a sound within the at least two sound signals is moving faster than a speed represented by the threshold value; and

a sound output control module configured to output a sound signal reproduced in the portable terminal to the first piezoelectric element of the earphone, and to output the sound signal received from the at least one microphone to the second piezoelectric element of the earphone if it is determined that the ambient sound should be output to the earphone.

2. The portable terminal according to claim **1**, wherein the sound output control module is configured to synthesize the sound signal received from at least one of the plurality of microphones and the sound signal reproduced in the portable terminal for output to the earphone if it is determined that the ambient sound should be output to the earphone.

3. A portable terminal system comprising an earphone and a portable terminal,

the portable terminal including

a plurality of microphones,

a determination module configured to determine whether or not an ambient sound should be output to the earphone based on a sound signal received from at least two of the plurality of microphones by detecting a phase difference between at least two sound signals received from the at least two microphones, and determining that the ambient sound should be output to the earphone when the phase difference between the at least two sound signals is more than or equal to a threshold value, thereby indicating that a source of a sound within the at least two sound signals is moving faster than a speed represented by the threshold value, and

a sound output control module configured to output a sound signal reproduced in the portable terminal to the earphone, and to output the sound signal received from the at least one microphone if it is determined that the ambient sound should be output to the earphone,

the earphone including a piezoelectric element configured to

vibrate based on the sound signal reproduced in the portable terminal and received from the sound output control module to supply an air-conducted sound to an eardrum through an external auditory canal, and,

if it is determined that the ambient sound should be output to the earphone, vibrate based on the sound signal received from the at least one microphone and received from the sound output control module to supply a vibration sound to the eardrum through a bone portion or a cartilaginous portion around the external auditory canal.

4. A portable terminal system comprising an earphone and a portable terminal,

the earphone including

a first piezoelectric element configured to vibrate based on a sound signal received from the portable terminal to supply an air-conducted sound to an eardrum through an external auditory canal, and

a second piezoelectric element configured to vibrate based on the sound signal received from the portable terminal to supply a vibration sound to the eardrum through a bone portion or a cartilaginous portion around the external auditory canal,

the portable terminal including

a plurality of microphones,

a determination module configured to determine whether or not an ambient sound should be output to the earphone based on a sound signal received from at least two of the plurality of microphones by detecting a phase difference between at least two sound signals received from the at least two microphones, and determining that the ambient sound should be output to the earphone when the phase difference between the at least two sound signals is more than or equal to a threshold value, thereby indicating that a source of a sound within the at least two sound signals is moving faster than a speed represented by the threshold value, and

a sound output control module configured to output a sound signal reproduced in the portable terminal to the first piezoelectric element, and to output the sound signal received from the at least one micro-

phone to the second piezoelectric element if it is determined that the ambient sound should be output to the earphone.

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